General Physics I

Projectiles Continued
Circular Motion & Relative Motion
Ch3, Secs 3-4

Day 4, Video 1

Projectiles Continued

Question #1

As a projectile moves in a parabolic path, the velocity and acceleration vectors are perpendicular to each other

A. Everywhere along the path
B. At the peak of the path
C. Nowhere along the path
D. Not enough information is given

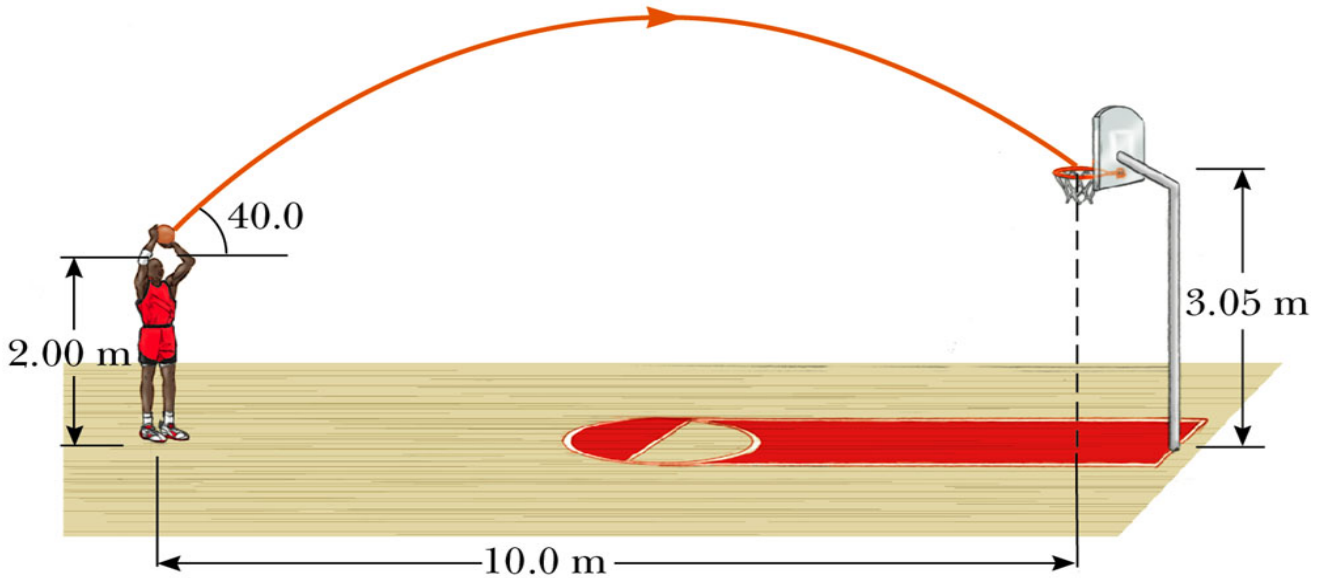
Question #2

How can you throw a projectile so that it has zero speed at the top of its trajectory?

A. Straight upward
B. 45° above the horizontal
C. Horizontally
D. It is not possible

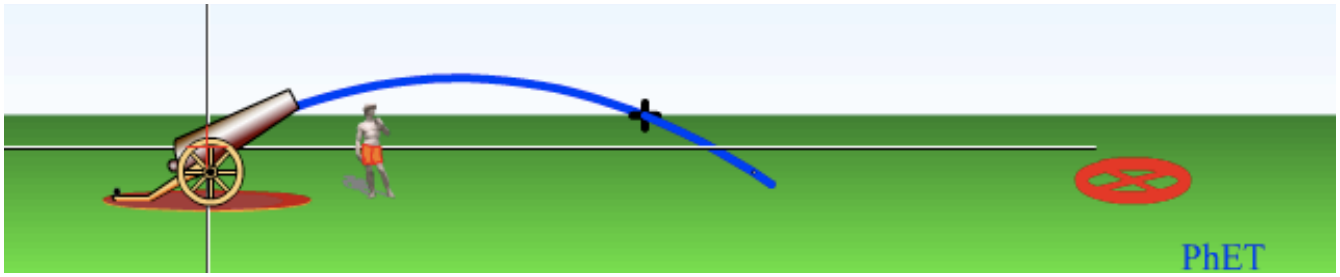
Example 1

A 2.00m tall basketball player is standing on the floor 10.0m from the basket. If he shoots the ball at a 40.0° angle with the horizontal, at what initial speed must he throw the basketball so that it goes through the hoop without striking the backboard? The height of the basket is 3.05m.



Range Equation

- Special Case - projectile starts and stops at the same height
- Question: How far does it travel?



https://phet.colorado.edu/en/simulation/projectile-motion

$$R = \frac{v_0^2 \sin(2\theta)}{g}$$

Max when $\theta = 45^\circ$

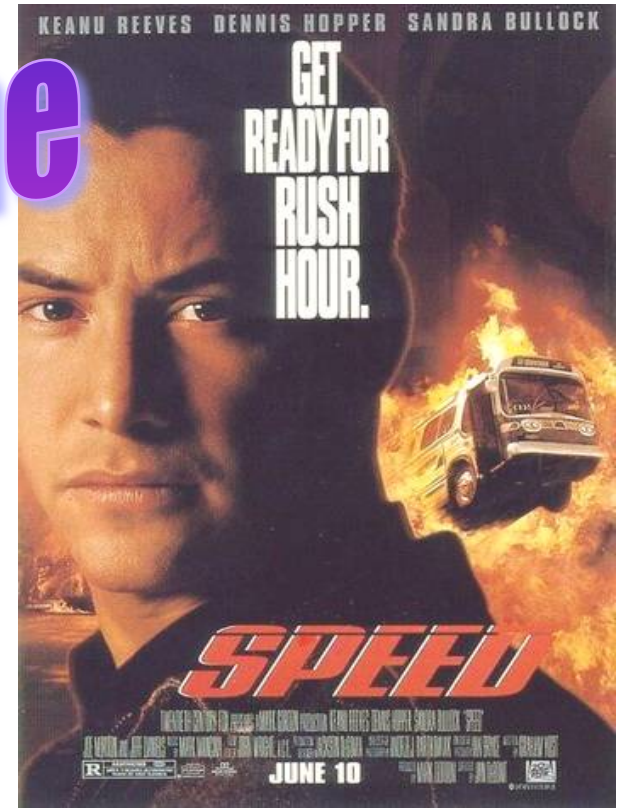
Day 4, Video 2

Projectiles Continued II

Example 2

Could the bus have made it?

Physics Goes to the Movies



Question #3

Suppose a projectile is launched with an initial horizontal velocity of 2.0 m/s and an initial vertical velocity of 2.0 m/s. What is the speed of the ball at the top of the parabola it travels along?

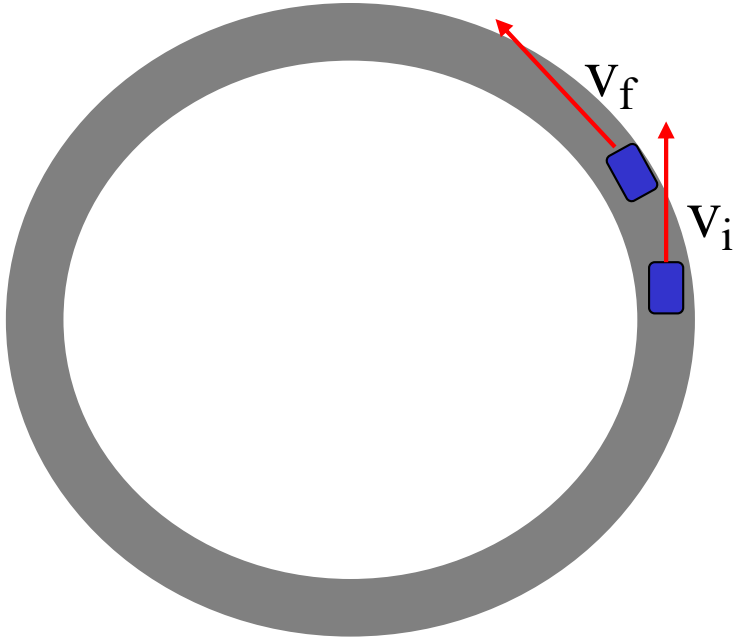
A. 0 m/s
B. 2.0 m/s
C. 2.8 m/s
D. 4.0 m/s

Day 4, Video 3

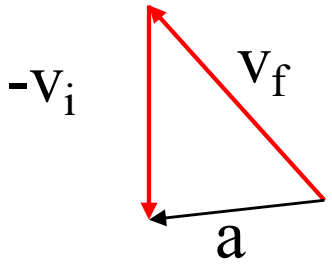
Centripetal Acceleration

Centripetal Acceleration

- Object moving in a circle with constant speed still has acceleration because the direction of the velocity vector is changing



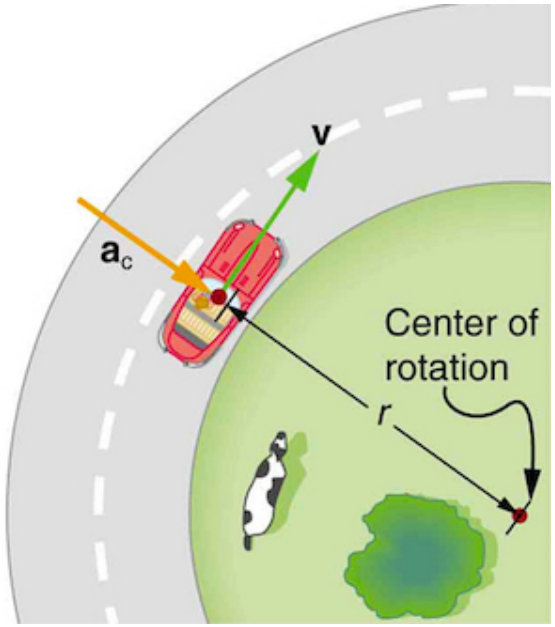
$$\vec{a}_{av} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$



Centripetal Acceleration

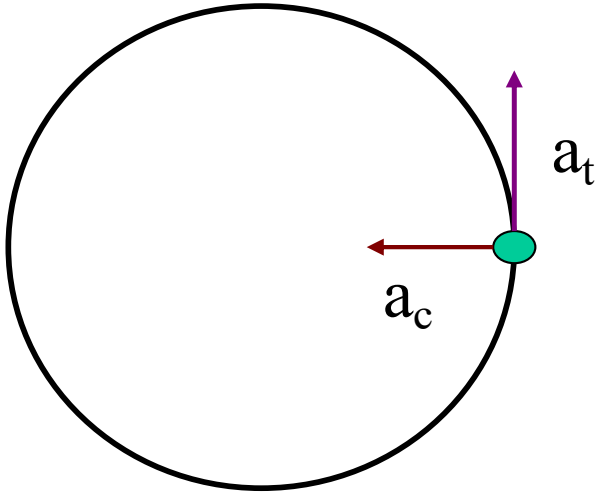
- a_c points towards the center of the circle with a magnitude

$$a_c = \frac{v^2}{r}$$



Circular Motion Acceleration

- 2 possible accelerations
  - a_c from moving in a circle
  - a_t if rotation is speeding up or slowing down
- Total $a = \sqrt{a_c^2 + a_t^2}$



Question #4

An object moves in a circular path with constant speed *v*. Which of the following is true concerning this object?

A. Its velocity is constant but its acceleration is changing
B. Its acceleration is constant but its velocity is changing
C. Both acceleration and velocity are changing
D. Velocity and acceleration remain constant.

Example 3

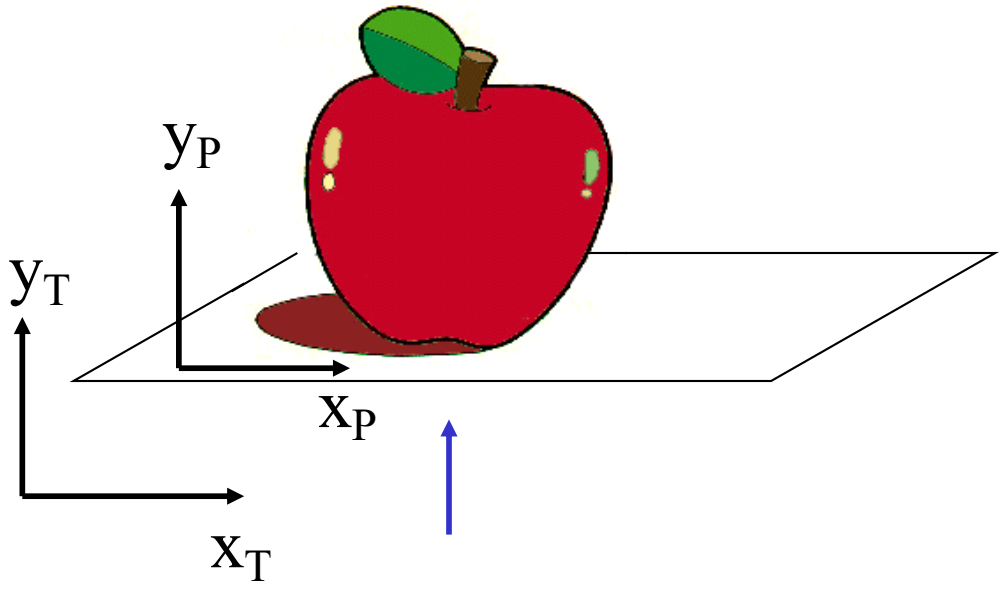
A race car starts from rest on a circular track of radius 400 m. the car's speed increases at the constant rate of 0.500 m/s^2. At the point where the magnitudes of the centripetal and tangential accelerations are equal, determine (a) the speed of the race car, (b) the distance travelled, and (c) the elapsed time.

Day 4, Video 4

Relative Motion

Relative Displacement

- Description of motion depends on frame of reference
  - Frame of reference = particular choice of coordinate system

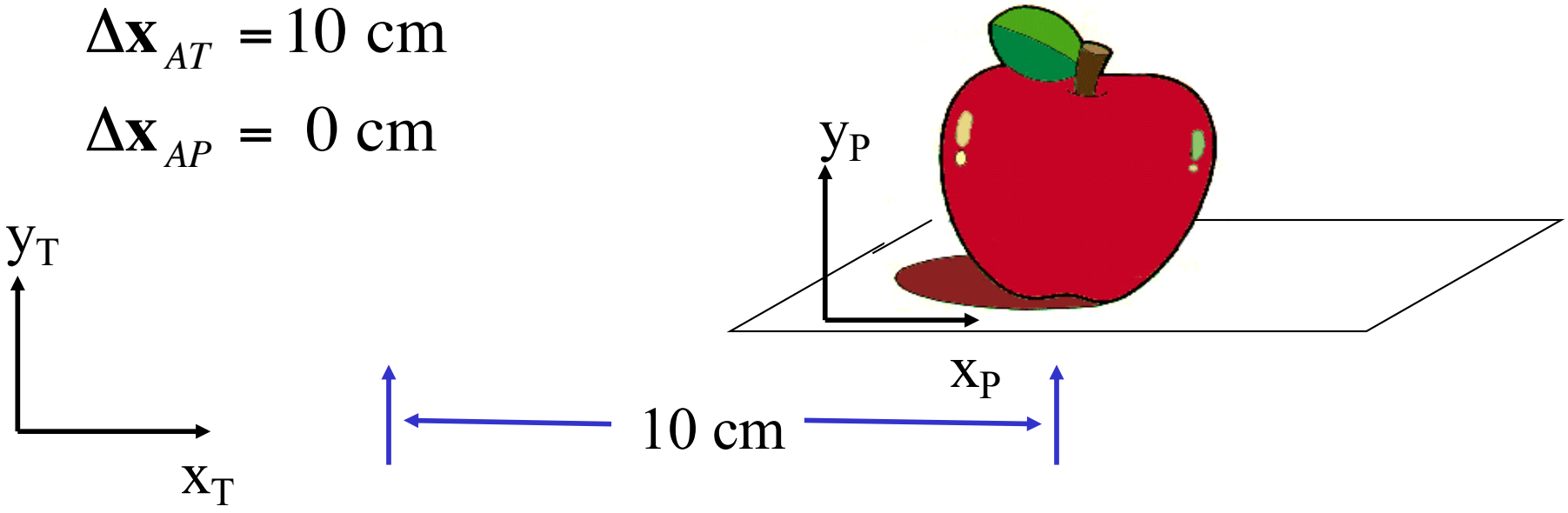


Relative Displacement

- Description of motion depends on frame of reference
  - Frame of reference = particular choice of coordinate system

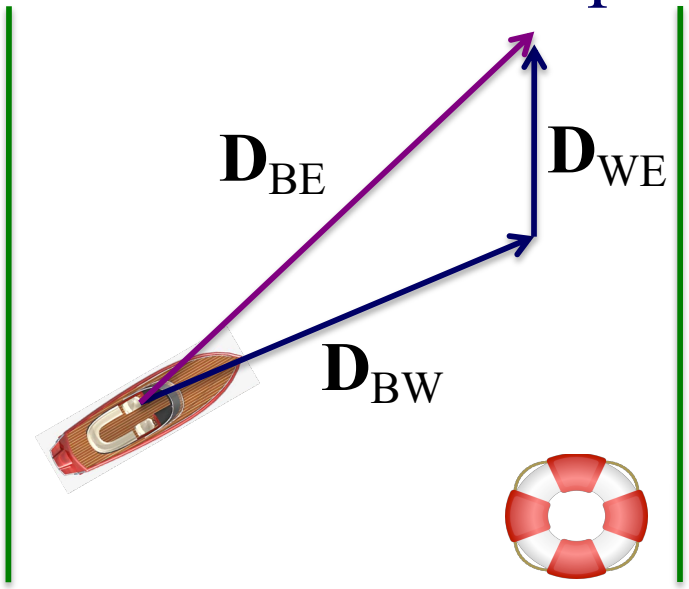
$\Delta \mathbf{x}_{AT} = 10$ cm

$\Delta \mathbf{x}_{AP} = 0$ cm



Relative Displacement

- To keep track of the vectors you are adding
  - Inner subscripts match
  - Outer subscripts are same as sum



$$\vec{D}_{BE} = \vec{D}_{BW} + \vec{D}_{WE}$$

$$\vec{D}_{WE} = -\vec{D}_{EW}$$

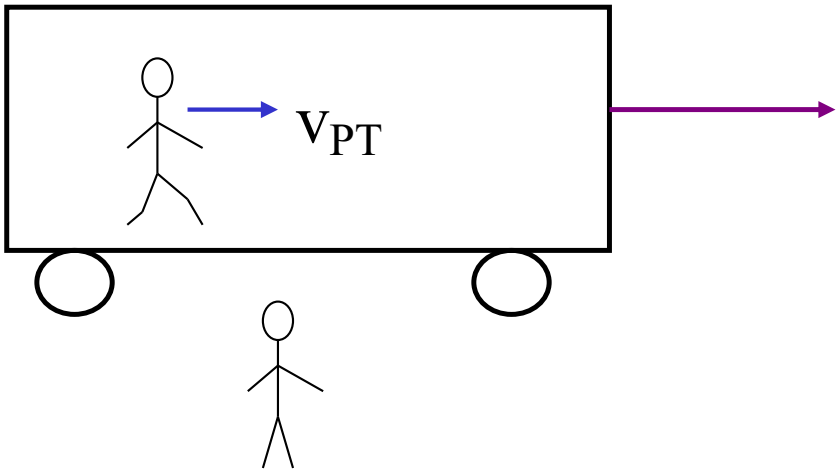
Question #5

Suppose you are walking down a conveyor belt in the direction it is moving. A dot painted on the belt travels 10 m. During the same time you walk 5 m along the belt. What is your displacement with respect to the ground?

A. 5 m
B. 10 m
C. 15 m
D. 0 m
E. 20 m

Relative Velocity

- The description of velocity depends on frame of reference (coordinate system)
- Example: A person walks at 3 mph down the isle of a train traveling at 45 mph.



$$\vec{v}_{PT} = 3\,\text{mph}$$
$$\vec{v}_{TE} = 45\,\text{mph}$$
$$\vec{v}_{PE} = \vec{v}_{PT} + \vec{v}_{TE} = 48\,\text{mph}$$

Day 4, Video 5

Relative Motion II

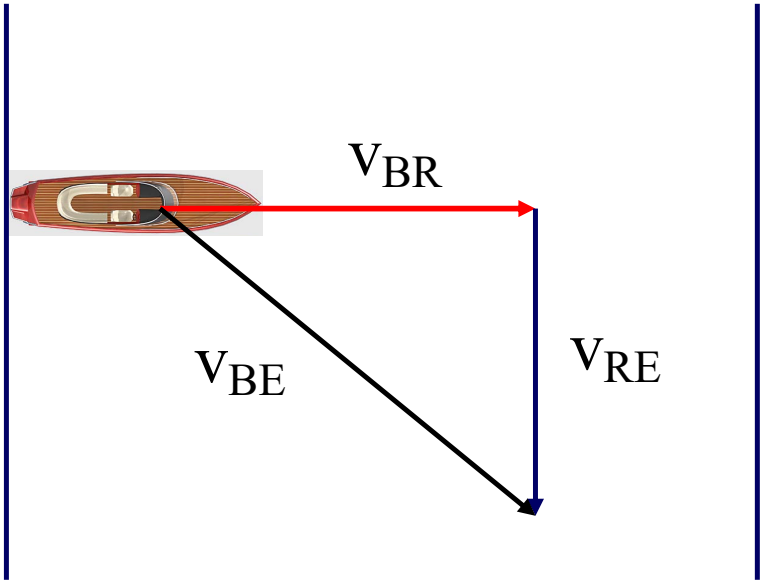
Question #6

You want to cross a swift river in a boat and land on the other bank directly across from where you started. You should aim the boat.

A. Directly across the river
B. Aimed slightly upstream
C. Aimed slightly downstream
D. Directly upstream

2-D Relative Velocity

- A boat crosses a river in a strong current



$$\vec{v}_{BE} = \vec{v}_{BR} + \vec{v}_{RE}$$

Add vectors by breaking into X and Y components

$$\vec{v}_{BE} = -\vec{v}_{EB}$$

Example 4

A plane traveling at 300 mi/h due east enters a region where the wind is blowing 100 mi/h 30° north of east. What is the new velocity of the aircraft?

Question #7

A river is flowing at 6 mph. A person is swimming directly upstream at 3 mph. After two hours, where will the person be?

A. 6 miles upstream
B. 3 miles upstream
C. Where they started from
D. 3 miles downstream
E. 6 miles downstream

Big Ideas

- Centripetal acceleration
  - acceleration due to motion in a circle

$$a_c = \frac{v^2}{r}$$

- Relative Motion
  - displacement, velocity, etc depend on frame of reference

$$\vec{v}_{AB} = \vec{v}_{AC} + \vec{v}_{CB}$$